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THE UNIVERSITY OF ALBERTA

THE RELATION BETWEEN FOUR SELECTED TEACHER CHARACTERISTICS AND STUDENT ACHIEVEMENT IN GRADE TWELVE MATHEMATICS

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

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by

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ABSTRACT

This study investigates, for the school year 1957-58, the relation between four selected characteristics of Alberta Grade XII mathematics teachers and the results of their students in the Mathematics 30 final examination. The following characteristics are considered: (1) the number of years of academic and professional training beyond Grade XII; (2) the number of university-level mathematics courses taken; (3) the number of years of teaching experience; (4) the subject-field preference for teaching. The study compares teachers in city school systems and teachers in non-city systems with respect to the four characteristics. It also compares students in city systems and students in non-city systems with respect to their results in the mathematics examination.

Data were obtained from the returned questionnaires of the Alberta Royal Commission on Education (1958) and from the official examination records of the Department of Education. The method of analysis involved the use of chi-square and analysis of variance. Mathematics scores were transformed statistically to remove the effects of differences in students' mental abilities.

The study found a significant positive relation between students' results in the Mathematics 30 final examination and each of the four teacher characteristics,

length of academic and professional training beyond Grade XII, number of university-level mathematics courses taken, length of teaching experience, and subject-field preference for teaching.

The study brought out some significant differences between teachers in city school systems and teachers in non-city systems. City teachers surpass non-city teachers very significantly in length of acadmic and professional training and in number of university-level mathematics courses taken, but not very significantly in length of teaching experience. The two groups do not differ significantly in their subject-field preference for teaching.

The study also revealed a very significant difference in results in the Mathematics 30 final examination between students in city school systems and students in non-city systems. The results of city students are much higher than those of non-city students.

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CHAPTER I

THE PROBLEM

I. INTRODUCTION TO THE PROBLEM

It has always been recognized that the quality of instruction in the classroom is dependent primarily upon the competence of the teacher. Indeed, in the final analysis, the quality of teachers is one of the two most important factors in the success or failure of education.[1] If the efforts of education are to be successful, there will have to be methods to assess the competence of teachers to insure that this competence is of a satisfactory standard.

Teacher competence may be measured in terms of the many separate personal characteristics of the teacher. Some of these characteristics, such as interest, initiative, and tolerance, relate directly to the personality of the teacher; they are subjective characteristics and, because of their subjectivity, are difficult to measure. Others, such as professional training, special subject-field preparation, teaching experience, and subject-field preference for teaching, relate only indirectly or not at all to the

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[1] Report of the Royal Commission on Education, (Edmonton: Government of Alberta, the Queen's Printer, 1959), p. 180.

personality; they are factual characteristics and, as such, can be measured quite reliably.

To determine the relation between each of these characteristics and the competence of the teacher, it is necessary to have some criteria for the measurement of competence. Such criteria are difficult to establish; they vary with the many conflicting viewpoints regarding the goals of education. However, there has long been some agreement amongst educators that one of the ultimate criteria of teacher competence is student achievement.[2]

Student achievement, in turn, may be defined in various ways, each dependent upon its own selection of objectives. The results of terminal examinations in a subject field are one way and at least one study indicates that the Alberta Department of Education Examinations in Grade XII are valid measures of educational achievement.[3]

The present study investigates the relation between certain measurable characteristics of teachers and their competence in teaching. The characteristics considered are

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[2]The two reports of the Committee on the Criteria of Teacher Effectiveness (Review of Educational Research, 22: 238-263, June, 1952, and Journal of Educational Research, 46: 641-658, May, 1953) have listed student achievement as one of the ultimate criteria of teacher competence.

[3]D. B. Black, "The Prediction of Freshman Success in the University of Alberta From Grade XII Departmental Results," The Alberta Journal of Educational Research, 6:47, March, 1960.

academic and professional training, special subject-field preparation, teaching experience, and subject-field preference for teaching. The criterion used is student achievement in mathematics as measured by a terminal examination.

II. STATEMENT OF THE PROBLEM

This study investigates the relation between four measurable characteristics of Grade XII mathematics teachers in Alberta schools in 1957-58 and the results of the students of these teachers in the Mathematics 30 final examination of that year. The following characteristics are considered: (1) the number of years of academic and professional training beyond Grade XII; (2) the number of university-level mathematics courses taken; (3) the number of years of teaching experience; (4) the subject-field preference for teaching.

The Major Problem

Do differences in the above four characteristics of Grade XII mathematics teachers reflect significant differences in the results of the students of these teachers in the Mathematics 30 final examination?

The Minor Problems

(1) Are there any significant differences in the above four characteristics between teachers in city school systems

and teachers in non-city systems such as divisions, counties, and independent districts?

(2) Are there any significant differences in results in the Mathematics 30 final examination between pupils taught in city schools and pupils taught in non-city schools?

III. IMPORTANCE OF THE STUDY

The teacher characteristics considered in this study currently occupy central positions in several matters of direct concern to teachers. The number of years of professional training and the number of years of teaching experience are key factors in the structure of teachers' salary schedules: within limits, the salary of the teacher is proportional to his training and experience. Those responsible for this structure agree to assume that training and experience correlate positively with teaching competence but they want objective evidence for this assumption. Teacher-training institutions, recognizing the need of background content courses for teachers of special subject fields, want to know the optimum number of mathematics courses necessary for requisite competence in mathematics teaching. Administrators in charge of teacher placement want proof that a teacher is most productive of student growth when he is teaching in his preferred subject field. The implications of these statements clearly indicate the

need of a study of the present kind.

The present study parallels one recently completed by Lindstedt at the Grade IX level.[4] Both relate to the competence of mathematics teachers in the province of Alberta. The findings of the present study, together with those of the earlier one, should lead to more definite conclusions about some of the factors involved in the competence of mathematics teachers in Alberta.

IV. LIMITATIONS OF THE STUDY

This study is limited to those teachers in Alberta schools who completed and returned the Alberta Royal Commission on Education questionnaire (May, 1958) and who had checked Item 21 (7) in that questionnaire. (Item 21 (7) identifies the respondent as a teacher of Grade XII mathematics.) Of this group, only those teachers who taught Mathematics 30 are involved in the study.

In the case of schools operating on the semester basis, only those teachers are involved who taught in the last semester of the year; that is, those whose students wrote the Mathematics 30 examination in June.

The study excludes the teachers of the private schools

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[4]S. A. Lindstedt, "Teacher Qualifications and Grade IX Mathematics Achievement " (unpublished Master's thesis, The University of Alberta, Edmonton, Alberta, 1960).

in the province; the teachers of only the public and separate schools are involved.

V. BASIC ASSUMPTIONS

The following assumptions are basic to the study.

1. The responses recorded in the Questionnaire (defined below) represent the respondents' best judgements of the matters in question.

2. The data in the Principals' Form "A" Cards in the Department of Education, Province of Alberta, for 1957-58, specifying course assignments to teachers, are true.

3. The students involved in the study have been correctly identified with their respective teachers.

VI. DEFINITION OF TERMS

The following terms are defined as they are to be interpreted in the study.

(1) Teacher competence: the teacher's effectiveness, or ability to teach, as measured by an acceptable criterion.

(2) Questionnaire: the questionnaire used in 1958 by the Alberta Royal Commission On Education for the purpose of securing information on the teaching personnel of the province. The official name of this questionnaire is as follows: Province of Alberta, Royal Commission on Education, Survey of

Alberta Teacher Force, Individual Teacher's Report.

(3) Mathematics 30 final examination: the official Mathematics 30 examination of June 1958, prepared and administered by the High School and University Matriculation Examinations Board of the Department of Education, Province of Alberta.

(4) Results in the Mathematics 30 final examination: the students' scores on the above examination as reported to the students, but transformed as discussed on page 30. (These scores are expressed as numbers on a scale ranging from 0 to 100.)

(5) Teacher in a city school system: a teacher who checked Item 11 B(1) or Item 11 B(6) in the Questionnaire.

(6) Teacher in a non-city school system: a teacher who checked one of the following items in the Questionnaire: 11 a, 11 B(2), 11 B(3), 11 B(4), 11 B(5), 11 B(7), 11 B(8), or 11 B(9).

CHAPTER II

REVIEW OF RELATED RESEARCH

I. SCOPE OF THE REVIEW

Research in the whole field of teacher competence is very extensive. Many studies have been undertaken, especially in recent decades, in an attempt to establish objective and reliable measures of teaching ability. A bibliography by Domas and Tiedman alone lists over one thousand studies of various kinds in this area.[1]

To get a general idea of the extent and nature of the research studies in the field of teacher competence, one may turn to a classification of teacher competence studies by Ackerman. He categorizes as follows the various types of teacher evaluation for competence and effectiveness:

1. studies based on the consensus of expert opinion as to the characteristics and prerequisites of competency and efficiency
2. studies using school grades, practice-teaching grades and ratings of student teaching as the criteria of teaching efficiency
3. studies using supervisory in-service ratings, self-ratings and ratings by fellow teachers as the criteria of teacher competence
4. studies using pupil opinion and reaction as the criteria of teacher effectiveness
5. studies using measured pupil change as the

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[1]S. J. Domas and D. V. Tiedman, "Teacher Competence: An Annotated Bibliography," Journal of Experimental Education, 19:103-218, December, 1950.

criterion of teacher competence[2]

Because of the limitations of time and space necessarily imposed on a study of the present kind, the research reviewed in this chapter is restricted to those studies using measured pupil change as the criterion of teacher competence. Specifically, only those studies are reviewed which have attempted to determine the relation between pupil achievement or academic growth and the following teacher characteristics: the extent of academic and professional training, including special subject-field preparation, the length of teaching experience, and the subject-field preference for teaching. It is these studies that relate most directly to the present one.

A study recently completed by Lindstedt, because of its special importance in the present investigation, is reviewed separately in the latter part of the chapter.[3]

II. STUDIES ON ACADEMIC AND PROFESSIONAL TRAINING

Much of the present-day controversy in education centers around the professional preparation of teachers. Not a little has been written and spoken about the desira-

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[2]Walter J. Ackerman, "Teacher Competence and Pupil Change," The Harvard Educational Review, 24:273, Fall, 1954.

[3]S. A. Lindstedt, "Teacher Qualifications and Grade IX Mathematics Achievement" (unpublished Master's thesis, The University of Alberta, Edmonton, Alberta, 1960).

bility of longer training programs with greater emphasis on academic preparation. The Report of the Alberta Royal Commission on Education, for example, recommends that all teachers have a minimum of four years of university training, including a degree.[4] Dissenting opinions have been just as frequent. Indeed, the objective evidence itself is inconclusive.

Perhaps the earliest reported investigation of the relation between teacher training and pupil achievement was that of Rogers in 1924. Rogers gave the Monroe silent-reading tests to 166 classes in the third, fourth, and fifth grades. He reported that higher reading comprehension scores were in general accompanied by more teacher training.[5]

Another early study was that of Hughes in 1925. This study involved the teachers and pupils of physics classes of twenty-nine schools of various sizes. The teachers were grouped on the basis of the number of years of college physics they had had. The three tests used to measure student achievement were constructed to cover the basic material of

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[4]Report of the Royal Commission on Education, (Edmonton: Government of Alberta, The Queen's Printer, 1959), p. 187.

[5]Don C. Rogers, "The Effect of Experience and Training on Improvement in Silent Reading Comprehension", Chicago Schools Journal, 6:329-31, May, 1924, cited by Helen M. Walker (ed.), The Measurement of Teaching Efficiency (New York: The MacMillan Company, 1935), p. 146.

the texts most commonly used in the schools. The pupils were equated on the basis of intelligence. The following results were reported:

> In every test, the pupils who were taught by teachers who had majored in physics made average scores above the mean score of all pupils taking the test. In every test, the pupils who were taught by teachers who had not majored in physics made average scores less than the mean score of all pupils taking the test.[6]

In 1929, Bergman studied the factors which seemed most closely related to pupil success or failure as measured by educational tests, using data from 14,000 pupils gathered in the Michigan state cooperative testing program. He concluded that training has no appreciable influence on educational achievement within homogeneous groups of pupils.[7]

In 1933, Davis undertook an investigation into the relationship between the training of a large number of high school teachers and their success in getting pupils through the Minnesota State Board Tests of Pupil Achievenent. Subjects for the study came from ninety schools throughout Minnesota, only those schools being chosen which had a minimum of thirty pupils and three teachers. Altogether data

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[6]J. M. Hughes, "A Study of Intelligence and of the Training of Teachers as Factors Conditioning the Achievement of Pupils," School Review, 33:294, March-April, 1925.

[7]Walter G. Bergman, "The Determination of Norms" (Doctor's thesis, The University of Michigan, Ann Arbor, Michigan, 1929), p. 176, cited by Helen M. Walker (ed.), The Measurement of Teaching Efficiency (New York: The MacMillan Company, 1935), p. 146.

were collected from the records of 796 teachers of 13,460 pupils. Davis found that the students of teachers who had not had specialized training in the subjects which they taught scored higher on subject-matter achievement tests than did the students of teachers who had received such training.[8] A major exception was found in the results of the test in chemistry; the scores of the students whose teachers had had a college major or minor in chemistry were much higher than the scores of the students whose teachers had not had such training.[9]

More recently (1946), Stephens and Lichenstein conducted a study involving eighty-six Baltimore teachers of fifth-grade arithmetic. Only those classes were used that had had the same teacher throughout the term covered by the tests and only those pupils were involved who had been in class continuously during the term. The class achievement was determined by a formula which evaluated pupil growth in relation to mental age and was expressed as a class efficiency score, denoted C.E. The investigators reported that the

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[8]H. M. Davis, The Use of State High School Examinations as an Instrument for Judging the Work of Teachers (Teachers College Contributions to Education, No. 611. New York: Columbia University, 1934), p. 101.

[9]Ibid.

C.E.'s correlated negatively with the teacher's knowledge of arithmetic.[10]

During 1947-48, Schunert carried out a study, comprehensive in scope and advanced in research design, which sought, amongst other things, to determine the relation of the mathematical achievement of the student to the academic training of the teacher. The sample consisted of 100 schools selected from the population of Minnesota's 522 public secondary schools classified with respect to enrollment size and organizational type. It included 102 teachers of elementary algebra and 94 teachers of plane geometry and involved 3,919 pupils. The investigator found no significant association between the mathematical achievement of the student and the amount of college mathematics studied by the teacher.[11]

In 1955, Morsh, Burgess, and Smith conducted a study designed to develop a reliable criterion of instructor effectiveness. The work was done with 121 instructors in

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[10] J. M. Stephens and A. Lichenstein, "Factors Associated with Success in Teaching Grade Five Arithmetic," Journal of Educational Research, 40:694, May, 1947.

[11] Jim Schunert, "The Association of Mathematical Achievement with Certain Factors Resident in the Teacher, in the Teaching, in the Pupil, and in the School," Journal of Experimental Education, 19:233, March, 1951.

an aircraft mechanics course at an Air Force installation. The effectiveness measure used was the actual subject-matter achievement of an instructor's students. As in the case of the preceding two studies reviewed, little relation was found between the instructors' knowledge of subject matter and the gains made by the students.[12]

In 1959, McCall and Krause, using a sample of seventy-three sixth grade teachers from rural and city schools in North Carolina, sought to measure teacher competence by using as the criterion the amount of good all-round growth each teacher produced in his class. The initial status of the pupils in September and the final status in May in nine areas of pupil growth were measured. The growths each teacher produced in these nine areas were combined, with acceptable weightings according to importance, into a single criterion-of-merit score. The following findings are of interest:

> Training, an almost universally employed basis for evaluating teacher merit and fixing salaries, was somewhat better than drawing shuffled names out of a hat (r=.13).
>
> The teacher's knowledge of subject matter showed no correlation (-.06) with efficiency.[13]

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[12]Joseph E. Morsh, G. C. Burgess, and P. N. Smith, "Student Achievement as a Measure of Instructor Effectiveness," Journal of Educational Psychology, 47:88, February, 1956.

[13]W. A. McCall and G. R. Krause, "Measurement of Teacher Merit for Salary Purposes," Journal of Educational Research, 53:73, October, 1959.

This study again suggested little relationship between the training and subject matter background of the teacher and the achievement of the student.

III. STUDIES ON TEACHING EXPERIENCE

The role of experience in the making of an effective teacher is a much disputed one. It seems natural to assume that, other things being equal, the teacher with the greater amount of experience is the one likely to be more competent. Whatever the truth of this assumption, many school systems today use it as a guide in the important areas of teacher selection and promotion and in the equally important area of salary determination. However, not all studies which attempt to relate pupil growth to teacher experience conclude that this relation is either positive or significant.

Investigations into the relation between teaching experience and student achievement have paralleled closely those into the relation of academic and professional training to achievement. Indeed, they have usually been the same single studies treating both problems simultaneously. This was the case with many of the studies already reviewed here.

Of this group, the study by Rogers revealed that "higher reading comprehension scores of pupils were in general accompanied by greater teacher experience, up to

8 or 9 years."[14]

Bergman's study brought out the conclusion that the experience of the teacher has no appreciable influence on the achievement of pupils within homogeneous groups.[15]

Davis found that pupils of teachers with two or more years of experience were more successful in passing the Minnesota State Board Test than were pupils of teachers with one year of experience. Interestingly enough, pupils of teachers with more than two years of experience exceeded in achievement little or not at all the pupils of teachers with just two years of experience.[16]

Schunert's study of 296 algebra and geometry teachers and their 3,919 pupils produced the following conclusion about the relation between teaching experience and student achievement:

> Classes taught by teachers who had more than eight years of experience exceeded the achievement of classes taught by teachers of less experience. No significant difference was found between the achievement of classes taught by teachers of less than two years experience and achievement of classes taught by teachers having from two to eight years of experience.[17]

On the same question, Stephens and Lichenstein reported as follows:

> Judging from the gross relationships, experience seems beneficial for the graduates of the State Normal

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[14]Rogers, loc. cit. [15]Bergman, loc. cit.

[16]Davis, loc. cit. [17]Schunert, loc. cit.

> School (range of experience, 0-9 years) and slightly detrimental for the graduates of the City Training School (with a range of from 4 to 24 years experience).[18]

The investigators concluded that in general the C.E.'s (Class Efficiency scores) showed a slight positive correlation with experience, with the positive influence of experience being especially true (r=0.37) for the younger teachers.[19]

McCall and Krause, in their study which measured teacher competence in terms of all-round pupil growth, drew the following conclusion about the role of experience in competence:

> Years of service, usually referred to as experience, another customary basis for determining the worth and salary of teachers, showed a zero (-.04) correlation with merit. This finding is supported by the further fact that young teachers averaged higher criterion scores, or over-all growth in pupils, than did older teachers.[20]

These findings are rather inconsistent and support no definite conclusion.

In other studies of the relationship of the teacher's classroom experience to the academic achievement of his students, the findings appear to be no more consistent. Moss, Loman, and Hunt reported (1929) that a chemistry achievement test based on material found in the most commonly used textbooks in college courses of introductory chemistry

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[18] Stephens and Lichenstein, op. cit., p. 690.

[19] Ibid. [20] McCall and Krause, loc. cit.

was administered to 6,667 students at the beginning and end of an elementary course in twenty-eight colleges and universities. Classes were equated on the basis of size, average intelligence of students, and previous training in chemistry. The efficiency of the instructors was determined by the adjusted average difference between students' initial and final scores. The highest median scores were obtained by pupils of instructors who had been teaching from one to eleven years. A noticeable decrease was found in the median scores of pupils of instructors with twelve or more years of teaching experience.[21]

In a study conducted in 1935, Betts administered a test consisting of twelve sub-tests to two contrasting groups of teachers: novices and experienced. (There were 54 teachers teaching an aggregate of 1,214 pupils.) These teachers rated themselves on a number of variables thought to be essential to successful teaching, for example: the teacher's acuity of perception of the relative importance of certain teaching abilities, the teacher's ease in adapting himself to difficult tasks, and the teacher's ability to adapt himself to certain conditions of teaching. The scoring scheme was so revised that the experienced teachers did in fact score higher than the novices. The test was then

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[21] F. A. Moss, W. M. Loman, and T. Hunt, "Impersonal Measurement of Teaching," Educational Record, 10:40-50, 1929.

administered a second time. The criterion of teaching ability was pupil scores on a standardized achievement test. The correlation between the novice-experienced dimension and pupil change with pupil ability and age held constant was found to be highly significant (almost six times its probable error).[22]

More recently (1945), Rolfe evaluated the teaching ability of fifty-seven seventh and eighth-grade teachers of one-room and two-room rural schools in Wisconsin. Tests judged to be valid measures of stated educational objectives were administered to the pupils before and after instruction in several units in the area of citizenship. The differences between the initial and final scores were adjusted for individual pupil differences in initial achievement, intelligence, and socio-economic status by means of multiple-regression. The difference between the average of the actual gains in achievement of a teacher's pupils and the average gains predicted for the group was used as an indication of the teacher's efficiency. Rolfe concluded that the experience of the teacher contributes little when measured against the criterion of pupil change as set up in his study ($r=-.17$).[23]

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[22] G.L. Betts, "Pupil Achievement and the NS Trait in Teachers," Helen M. Walker (ed.), The Measurement of Teaching Efficiency (New York: The MacMillan Company, 1935), p. 195.

[23] J. F. Rolfe, "The Measurement of Teaching Ability: Study No. 2," The Journal of Experimental Education, 14:74, 1945.

It is interesting to note not only the inconsistency in the above three findings (as in the earlier ones) but also the fact that one of them was significantly negative: achievement scores decreased noticeably when teaching experience was twelve years or longer.

IV. THE STUDY BY LINDSTEDT[24]

Relation to the Present Study

Lindstedt investigated the competence of Grade IX mathematics teachers who were teaching in Alberta schools in May, 1958. His study is of special importance to the present one because of the similarity of specific purposes of the two studies: Both sought to determine the relation between four objectively measurable characteristics of Alberta mathematics teachers (training, experience, number of university-level mathematics courses taken, and subject-field preference for teaching) and the achievement of the students of these teachers in the final examination in mathematics. For the most part, both studies were identical in design; the specific problems, the sources and organization of data, and the method of analysis were basically the same.

However, in addition to the fact that the two studies

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[24]Lindstedt, loc. cit.

were carried out at different grade levels, two important differences are noted: (1) Lindstedt investigated the main problem using only a sample of the total teacher population (161 out of 728, or about 22 per cent of the total); the present study used almost the entire population (257 out of 269, or about 96 per cent of the total). (2) Lindstedt's study, unlike the present one, did not take account of differences in the mental abilities of the students.

Lindstedt gives two reasons for his not using the total population of students:

> (1) the total number of students was too large for economy of time in compilation, and (2) many of the large schools, particularly in the cities, employ more than one teacher of mathematics, making it impossible to relate the results of their pupils, grouped by schools, to the individual teachers.[25]

To the question of differences in mental ability, Lindstedt makes no reference. The conjecture of the present writer is that Lindstedt may have felt that he did not have a sufficiently valid measure of the students' abilities. The students had written the School and College Ability Test (SCAT) at the time of the regular examinations, but since a large part of this test is quantitative, the scores on it would reflect, to a large degree, the influence of the mathematics teacher. The fact that the use of such a test would have invalidated the study probably compelled

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[25]Lindstedt, op. cit., p. 9.

Lindstedt to disregard the question of differences in ability.

Summary of Findings

The main problem. The study found no significant relation between the academic and professional training of the teacher and the mathematics achievement of the student when the length of that training was less than four years. When the length of training reached or exceeded four years, the relation became significant. The same conclusion was reached when the sample of 161 teachers used in the study was reduced to contain only the 90 teachers who had indicated preference for teaching in the mathematics-science field.

The findings with respect to teaching experience were rather inconsistent. The study brought out a significant relation between teaching experience and student achievement when the length of experience was only one year or when it was ten years or more. However, it was pointed out in the study that the finding relative to teachers with one year of experience was somewhat inconclusive because the sample of 161 contained only six such teachers. The study also revealed that teachers with five to nine years of teaching experience were more effective than teachers with three or four years of experience but that there was no difference in competence between teachers with five to nine

years of experience and teachers with less than three years of experience.

Pursuing the problem further, Lindstedt investigated the relation between achievement and both characteristics, training and experience, working together. Using two-way analysis of variance, he found that successive increases in both training and experience were accompanied by successive improvement in student achievement. He concluded this point by saying

> Teacher effectiveness is made up of the two faces of the same coin; one face is experience, the other is training. A considerable amount of polishing, (at least 5 years of experience and 4 years of training), is needed to produce any significant brightening of the coin.[26]

The finding with respect to the relation between achievement and specific mathematical background agrees with those of the majority of the studies reviewed earlier: Student achievement and the number of university-level mathematics courses taken by the teacher are not significantly related. However, the study did find a significant relation between achievement and subject-field preference for teaching: those teachers who had indicated preference for teaching in the mathematics-science field had significantly higher student achievement in mathematics than did the teachers who had indicated preference for a different

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[26]Lindstedt, op. cit., p. 51.

subject field.

The minor problems. In investigating the differences between city teachers and non-city teachers relative to the four teacher characteristics in question, Lindstedt used the entire population of 728 teachers. He found that city teachers surpassed non-city teachers in length of academic and professional training and in extent of mathematics preparation. City teachers were also more favorably placed with respect to subject-field preference for teaching. However, there was no significant difference between these two groups of teachers with respect to length of teaching experience.

The comparison between city students and non-city students relative to their achievement in mathematics revealed that both groups achieved equally well; the study (based on a sample of 5,590 students) disclosed no significant difference in final examination results between city students and non-city students.

V. SUMMARY OF CHAPTER

The findings of the studies reviewed are somewhat inconsistent and do not seem to warrant any definite conclusions. Most of the studies concerned with the relation between student achievement and the teacher's professional

training and academic background have found that this relation is not significant. Those investigating the relation between student achievement and the teacher's classroom experience are less distinctly divided. One of the studies has found that training and experience in combination are positively associated with student achievement. The same study has found that teacher placement with respect to subject-field preference bears a significant relation to achievement. The need for further research is evident.

CHAPTER III

SOURCES, ORGANIZATION, AND METHOD OF ANALYSIS OF DATA

I. DATA ON TEACHERS

Sources

During 1958 the Alberta Royal Commission on Education, using individual teacher questionnaires, conducted a comprehensive survey of the teaching personnel of the province. The completed questionnaires, returned by over 99 per cent of the teachers, contain information concerning many objectively measurable characteristics of the individual teachers. Some of these characteristics are those involved in the present study. The information on them is contained in Items 11, 15, 22, 40 and 41 of the Questionnaire. (These items are reproduced in Appendix A of this study.) These items were the basic source of data on the teachers used in the study.

The Department of Education, Province of Alberta, receives early in the school year from each of the high school principals in the province, a report on the organization of that principal's school for the year. This report is contained on a card known as the Principal's Form "A" Card and specifies, among other things, the courses to be taught by a particular teacher during the year. The Principals'

Form "A" Cards for 1957-58 were used to identify the Mathematics 30 teachers used in the present study.

The Population

Examination of the Principals' Form "A" Cards revealed that there were 269 Mathematics 30 teachers in Alberta in 1957-58. Of this number, 259 had completed and returned the Questionnaire at the time of the Royal Commission investigation. With the exception of two teachers who were excluded because their students did not write the Mathematics 30 examination in June (their schools operated on the semester basis), this latter group became the teacher population for the study. This group of 257 teachers constitutes 95.5 per cent of the entire population of 269 Mathematics 30 teachers under study.

Of these 257 teachers, 37, or 14 per cent, identified themselves as teachers in city school systems and 220, or 86 per cent, as teachers in non-city systems. All of them responded to Item 15 of the Questionnaire; 250 responded to Item 22, 230 responded to Item 40, and 256 responded to Item 41.

II. DATA ON STUDENTS

Sources

The Examinations Branch of the Department of Education has the achievement record of the Grade XII students in

Mathematics 30 in 1957-58. The performance of each student in the June examination is recorded both as a raw score and as a transmuted score which is reported to the student. This record provided the data on student achievement in the Mathematics 30 final examination for the students involved in the study.

The Examinations Branch of the Department of Education also has a record of student performance on the mental ability test given each year to Grade IX students at the time of the regular examinations in June. The performance of each student on that test is expressed as a raw score and as a percentile. This record for June, 1955, provided the required data on the mental abilities of the students in the study.

The Population

The total number of students used in this study is 3,142. This number comprises all those students of the original 3,847 belonging to the 257 teachers used in the study that have recorded in the Department of Education a score on the Grade IX mental ability test of June, 1955. The student population used in this study therefore represents numerically 81.6 per cent of the original population of Mathematics 30 students.

Of these 3,142 students, 1,384, or 44 per cent, belong to teachers in city school systems and 1,758, or

56 per cent belong to teachers in non-city systems.

Test of Representativeness

Because the group of students actually worked with in the study was considerably smaller than the original group which it represented, it was considered advisable to test the representativeness of the group used. The method used and the degree of representativeness established are discussed in Appendix B of this study.

III. DATA USED IN TEACHER-STUDENT IDENTIFICATION

The Department of Education records student achievement in a particular examination subject by school. When there is only one teacher of Mathematics 30 in a particular school, he is automatically identified with his students; when there is more than one teacher, the problem of identification becomes difficult. For the eight schools in this study where the latter situation prevailed, every effort was made to find official school or teacher records which could be used to identify the student with his teacher. This method was possible in the case of five schools. In the remaining case of three schools (involving nine teachers and 334 students), official records were not available. The only alternative, other than to exclude the schools from the study (which seemed undesirable because of the large number of students that would have been lost) was to have each

teacher involved examine the June, 1958, Mathematics 30 student list for his school and try to recall the names of the students that were in his class. This alternative was taken in the study.

IV. TRANSFORMATION OF ACHIEVEMENT SCORES

In this study, the criterion of teacher competence is student achievement. Because student achievement is a variable dependent to a great degree upon student ability, it was considered necessary, in order to have a valid criterion, to take into account the individual mental abilities of the students. This necessity seemed strengthened by the fact that in most of the schools employing more than one teacher of Mathematics 30, students had been assigned to classes on the basis of ability; hence, different teachers taught classes of different ability. Consequently the achievement score originally assigned to each student was transformed statistically into a new score in a manner which took into account the student's raw score on the mental ability test he had written three years earlier in Grade IX (June, 1955). (The student's score on this test was considered to be the best available index of his mental ability.) Thus the scores used to represent student achievement in the study are scores which represent achievement in relation to mental ability.

Appendix C of this study contains a discussion of the method used to transform the scores. It also gives a brief description of the test used to measure the mental abilities of the students.

V. METHOD OF ANALYSIS

Statistical methods were used to analyze the data. In the minor problems, the data were appropriately cast into contingency tables and the probabilities of the distributions were calculated by the method of chi-square.[1] In each case the probability value, p, has been reported. (p represents the probability of entirely chance occurrence of the condition under observation.) The resulting interpretation is based on the value of p. A value of p greater than .05 ($p > .05$) is interpreted as nonsignificant; it indicates no significant difference between the groups being compared relative to the criterion. A value of p less than .01 ($p < .01$) is interpreted as very significant; there is a great difference between the groups being compared. If the value of p is between .05 and .01 ($.01 < p < .05$), a cautious interpretation is made; there is some difference between the groups.

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[1] J. P. Guilford, Fundamental Statistics in Psychology and Education (New York: McGraw-Hill Book Company, Inc., 1956), pp. 228-239.

In the major problem, contingency tables and chi-square, as described above, were used in the preliminary analysis of the data. A further investigation was carried out through the use of a more powerful technique: analysis of variance.[2] The conditions which must be satisfied before this technique can be applied were taken into consideration and, in the opinion of the investigator, they were satisfactorily fulfilled. Appendix D describes these conditions and discusses the degree to which they have been fulfilled in this study.

Where the analysis of variance necessitated the testing of the differences of means, interpretations were made on the basis of probabilities, as in the case of the chi-square method.

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[2]Helen M. Walker and Joseph Lev, Statistical Inference (New York: Henry Holt and Company, 1953), pp. 196-229; 348-386; George A. Ferguson, Statistical Analysis in Psychology and Education (New York: McGraw-Hill Book Company, Inc., 1959), pp. 227-263.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

I. THE MINOR PROBLEMS

Differences Between City School Teachers and Non-City School Teachers Relative to Four Selected Characteristics

The data relating to the first minor problem are presented in Tables I to IV, pages 34 to 37. Each of these tables contains data on the total number of Mathematics 30 teachers that answered the relevant item in the Questionnaire. (This number varies; not every teacher answered all four items. See page 27, The Population.) In each table, the vertical classification is into two groups: city teachers and non-city teachers. The horizontal classification is into four groups (except in one case, where it is into two) and is on the basis of the characteristic with respect to which the teachers are being compared. The value of chi-square (Chi^2), the degrees of freedom (df), and the probability value (p) have been calculated and are presented below the table.

The difference relative to academic and professional training. Table I compares city school teachers and non-city school teachers with respect to the number of years of academic and professional training that they have had beyond

Grade XII.

TABLE I

CITY SCHOOL TEACHERS COMPARED WITH NON-CITY SCHOOL TEACHERS RELATIVE TO NUMBER OF YEARS OF ACADEMIC AND PROFESSIONAL TRAINING BEYOND GRADE XII

	Number of years of Training				Totals
	Less than 4	4 but less than 5	5 but less than 6	6 or more	
City Teachers	2	11	8	16	37
Non-City Teachers	42	104	46	28	220
Totals	44	115	54	44	257

$Chi^2 = 22.90$; $df = 3$; $p < .01$

The chi-square test of independence brings out a highly significant difference between the two groups. City teachers far exceed non-city teachers in the length of their academic and professional training.

The difference relative to number of mathematics courses taken. Table II compares the same two groups of teachers with respect to the number of university-level mathematics courses they have taken.

Again the chi-square test brings out a very significant difference between the two groups of teachers. City teachers far exceed non-city teachers in the number of mathematics courses they have taken at university level.

TABLE II

CITY SCHOOL TEACHERS COMPARED WITH NON-CITY SCHOOL TEACHERS RELATIVE TO NUMBER OF UNIVERSITY-LEVEL MATHEMATICS COURSES TAKEN

	Number of Mathematics Courses				Totals
	1 or none	2 or 3	4 or 5	6 or more	
City Teachers	5	11	10	11	37
Non-City Teachers	53	85	61	14	213
Totals	58	96	71	25	250

$Chi^2 = 19.53$; $df = 3$; $p < .01$

The difference relative to teaching experience. Table III compares the city school teachers and the non-city school teachers with respect to the number of years of teaching experience that they have had.

The chi-square test reveals a difference between the two groups of teachers, but this difference is not very

significant. City teachers have more teaching experience than non-city teachers, but the difference is not so great as to be very significant.

TABLE III

CITY SCHOOL TEACHERS COMPARED WITH NON-CITY SCHOOL TEACHERS RELATIVE TO NUMBER OF YEARS OF TEACHING EXPERIENCE

	Number of Years of Experience				Totals
	9 or less	10 to 19	20 to 34	35 or more	
City Teachers	4	8	21	4	37
Non-City Teachers	52	80	77	10	219
Totals	56	88	98	14	256

$Chi^2 = 10.60$; $df = 3$; $.01 < p < .02$

The difference relative to teaching preference. Table IV shows the final comparison between the two groups of teachers. City teachers and non-city teachers are compared with respect to their subject-field preference for teaching.

The chi-square test fails to bring out any significant differences between the two groups. City teachers and non-city teachers do not differ significantly in their

preference of subject-field for teaching.

TABLE IV

CITY SCHOOL TEACHERS COMPARED WITH NON-CITY SCHOOL TEACHERS RELATIVE TO SUBJECT-FIELD TEACHING PREFERENCE

	Teaching Preference		Totals
	Mathematics-Science	Other	
City Teachers	32	2	34
Non-City Teachers	180	16	196
Totals	212	18	230

$Chi^2 = .01$; $df = 1$; $.90 < p < .95$

Difference Between City Students and Non-City Students Relative to Results in the Mathematics Examination

The data relating to the second minor problem are presented in Table V. The students are classified vertically into two groups: city students and non-city students. Horizontally, they are divided into ten categories, relative to their scores on the final examination.

The chi-square test of independence indicates a very significant difference between the two groups of students with respect to examination results. The scores of city

TABLE V

CITY STUDENTS COMPARED WITH NON-CITY STUDENTS RELATIVE TO RESULTS IN THE MATHEMATICS 30 FINAL EXAMINATION

	Scores on Examination										Totals
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	
City Students	4	17	40	134	266	371	305	173	59	15	1,384
Non-City Students	15	50	95	205	381	444	357	158	51	2	1,758
Totals	19	67	135	339	647	815	662	331	110	17	3,142

$Chi^2 = 58.48$; $df = 9$; $p < .01$

students are significantly higher than those of non-city students.

Summary of Differences

The statistical analysis indicates that the city teachers surpass the non-city teachers very significantly in length of academic and professional training and in extent of mathematical background, but not so significantly in length of teaching experience. The two groups do not differ significantly in their preference of subject field for teaching.

The analysis also shows that the city students surpass the non-city students very significantly in the examination results in Mathematics 30.

II. THE MAJOR PROBLEM: BASIC ANALYSIS

The Relation of Mathematics Examination Results to Four Selected Characteristics of Teachers

The data relating to the first analysis of the major problem are presented in Tables VI to XIII, pages 41 to 51. The relationship between examination results and teacher characteristics is investigated by the chi-square method and by the analysis of variance.

In the contingency tables, the examination scores of the students are grouped horizontally into ten categories in three cases and into eight categories in the fourth case.

Vertically, they are arranged into four groups in the first three cases and two in the fourth. The vertical arrangement is on the basis of the teacher characteristic in question.

The first analysis of variance table in each case presents a summary of the data on examination scores, suitably grouped. It also indicates the degree of homogeneity of variance of the data: the value of F_{max} (the ratio of the largest variance to the smallest) is reported along with the F-value required for significance. (This point is discussed fully in Appendix D.) The second table gives a summary of the analysis and indicates whether or not the means of the various groups differ significantly: if the reported value of F equals or exceeds the value of $F_{.01}$, there are significant differences among the means.

The relation to academic and professional training of teachers. Table VI shows the students' scores on the Mathematics 30 final examination arranged according to the number of years of academic and professional training of the teachers.

The chi-square test of independence shows very significant differences among the four groups of scores, indicating that there is a strong relation between Mathematics 30 results and the academic and professional training of the teachers.

TABLE VI

MATHEMATICS 30 RESULTS CLASSIFIED BY NUMBER OF YEARS OF ACADEMIC AND PROFESSIONAL TRAINING OF TEACHERS

Years of Training	Scores on Examination										Totals
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	
(1) Less than 4	5	12	19	36	94	91	71	19	5	2	354
(2) 4 but less than 5	11	30	65	147	273	324	240	127	35	2	1,254
(3) 5 but less than 6	1	14	22	82	134	190	166	65	16	3	693
(4) 6 or more	2	11	29	74	146	210	185	120	54	10	841
Totals	19	67	135	339	647	815	662	331	110	17	3,142

$Chi^2 = 105.87$; $df = 27$; $p < .01$

Tables VII(a) and VII(b), page 43, present the analysis of variance data and a summary of the analysis. The value of F (22.88) shows that there are significant differences among the means of the four groups of scores. Comparison of the means two at a time by means of the t-test[1] brings out significant differences in all cases. The differences in means between Groups (1) and (2) and between Groups (2) and (3) are significant at the .05 level of significance. The differences for the four remaining combinations are significant at the .01 level.

Specifically then, there is some difference in mathematics examination results between students whose teachers have had less than four years of academic and professional training and students whose teachers have had four but less than five complete years of training. The student achievement of teachers with five but less than six years of training is very much higher than that of teachers with less than four years of training. However, the student achievement of teachers with five but less than six years of training is not very much higher than that of teachers with four but less than five years of training.

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[1]George A. Ferguson, Statistical Analysis in Psychology and Education (New York: McGraw-Hill Book Company, Inc., 1959), p. 238; Henry E. Garrett, Statistics in Psychology and Education (New York: Longmans, Green and Co., 1959), pp. 212-216.

TABLE VII(a)

DATA FOR ANALYSIS OF VARIANCE: MATHEMATICS 30 RESULTS CLASSIFIED BY NUMBER OF YEARS OF ACADEMIC AND PROFESSIONAL TRAINING OF TEACHERS

	Number of Years of Training			
	(1) Less than 4	(2) 4 but less than 5	(3) 5 but less than 6	(4) 6 or more
Number of Students	354	1,254	693	841
Sum of Scores	18,007.00	66,297.00	37,771.50	48,595.50
Mean	50.87	52.87	54.50	57.78
Variance	228.61	255.60	219.36	214.23

Homogeneity of Variances: $F_{max} = 1.19$; $F_{.01} = 1.00$

TABLE VII(b)

SUMMARY OF ANALYSIS OF VARIANCE FOR DATA OF TABLE VII(a)

Source of Variation	Sum of Squares	Degrees of Freedom	Variance
Among Means	17,061.63	3	5,687.21
Within Conditions	779,857.69	3138	248.52

$F = 22.88$; $F_{.01} = 3.80$

The student achievement of teachers with six or more years of training far surpasses that of every other group of teachers.

The relation to number of mathematics courses taken by teachers. In Table VIII the students' scores have been grouped on the basis of the number of university-level mathematics courses taken by the teachers.

The chi-square test brings out very significant differences among the four groups of examination scores. It indicates that there is a close relation between Mathematics 30 results and the number of mathematics courses taken by the teachers.

The data for the analysis of variance and the summary of the analysis are shown in Tables IX(a) and IX(b), page 46. The value of F (47.22) indicates that the differences among the means are very significant. This is confirmed by the t-test which shows that all six differences are significant at the .01 level.

Table IX(a) shows that the means of the four groups of scores increase as the number of mathematics courses taken by the teachers increases. There is therefore a significant positive relationship between the two variables; results in the Mathematics 30 final examination are significantly improved when the teachers' background in university-level mathematics is increased.

TABLE VIII

MATHEMATICS 30 RESULTS CLASSIFIED BY NUMBER OF UNIVERSITY-LEVEL MATHEMATICS COURSES TAKEN BY TEACHERS

Number of Mathematics Courses	Scores on Examination										Totals
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	
(1) 1 or none	6	16	36	75	122	127	91	31	5	1	510
(2) 2 or 3	5	30	48	95	185	231	179	83	24	0	880
(3) 4 or 5	6	12	28	126	228	295	236	124	46	6	1,107
(4) 6 or more	1	7	19	41	105	157	146	89	35	10	610
Totals	18	65	131	337	640	810	652	327	110	17	3,107

$Chi^2 = 134.27$; $df = 27$; $p < .01$

TABLE IX(a)

DATA FOR ANALYSIS OF VARIANCE: MATHEMATICS 30
RESULTS CLASSIFIED BY NUMBER OF UNIVERSITY-
LEVEL MATHEMATICS COURSES TAKEN BY TEACHERS

	Number of Mathematics Courses			
	(1) 1 or none	(2) 2 or 3	(3) 4 or 5	(4) 6 or more
Number of Students	510	880	1,107	610
Sum of Scores	25,285.00	46,370.00	61,478.50	35,775.00
Mean	49.58	52.69	55.53	58.65
Variance	244.94	256.78	231.98	244.85

Homogeneity of Variances: $F_{max} = 1.11$; $F_{.01} = 1.00$

TABLE IX(b)

SUMMARY OF ANALYSIS OF VARIANCE
FOR DATA OF TABLE IX(a)

Source of Variation	Sum of Squares	Degrees of Freedom	Variance
Among Means	26,847.80	3	8,949.27
Within Conditions	588,133.15	3103	189.54

$F = 47.22$; $F_{.01} = 3.80$

The relation to teaching experience of teachers. The data for determing the relation between Mathematics 30 results and the number of years of teaching experience of the teachers are presented in Tables X, XI(a), and XI(b), pages 48 and 49.

The chi-square test applied to the data in Table X shows significant differences among the four groups of scores. The analysis of variance (Tables XI(a) and XI(b)) shows an F-value of 12.59, which is significant at the .01 level. When the means are compared and the differences tested, two insignificant and four significant differences are found. The differences in means are insignificant between Groups (1) and (2) and between Groups (1) and (4). The differences for all other pairs are significant beyond the .01 level.

Thus there is no difference in student examination results between teachers with nine or less years of teaching experience and teachers with ten to nineteen years of experience. Similarly, there is no difference in results between teachers with thirty-five or more years of experience and teachers with nine or less years of experience. Teachers with ten to nineteen years of experience produce better student results than do teachers with thirty-five or more years of experience. The results of teachers with twenty to thirty-four years of experience are better than those of any other group.

TABLE X

MATHEMATICS 30 RESULTS CLASSIFIED BY NUMBER OF YEARS OF TEACHING EXPERIENCE OF TEACHERS

Years of Experience	Scores on Examination										Totals
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	
(1) Less than 9	3	11	20	53	106	138	84	35	14	0	464
(2) 10-19	10	20	44	113	182	238	209	107	26	4	953
(3) 20-34	3	24	53	144	294	365	322	174	68	11	1,458
(4) 35 or more	3	11	17	26	61	73	47	15	2	2	257
Totals	19	66	134	336	643	814	662	331	110	17	3,132

$Chi^2 = 64.09$; $df = 27$; $p < .01$

TABLE XI(a)

DATA FOR ANALYSIS OF VARIANCE: MATHEMATICS 30
RESULTS CLASSIFIED BY NUMBER OF YEARS OF
TEACHING EXPERIENCE OF TEACHERS

	Number of Years of Experience			
	(1) 9 or less	(2) 10-19	(3) 20-34	(4) 35 or more
Number of Students	464	953	1,458	257
Sum of Scores	24,402.00	51,361.50	81,579.00	12,943.50
Mean	52.59	53.89	55.95	50.36
Variance	228.39	263.42	247.53	256.11

Homogeneity of Variances: $F_{max} = 1.15$; $F_{.01} = 1.00$

TABLE XI(b)

SUMMARY OF ANALYSIS OF VARIANCE
FOR DATA OF TABLE XI(a)

Source of Variation	Sum of Squares	Degrees of Freedom	Variance
Among Means	9,461.54	3	3,153.85
Within Conditions	783,737.32	3128	250.56

$F = 12.59$; $F_{.01} = 3.80$

The relation to teachers' subject-field preference for teaching. Table XII shows the students' scores arranged into two groups relative to the teachers' subject-field preference for teaching. Again the chi-square test shows a highly significant difference.

TABLE XII

MATHEMATICS 30 RESULTS CLASSIFIED BY TEACHERS' SUBJECT-FIELD PREFERENCE FOR TEACHING

Teaching Preference	Scores on Examination								Totals
	1-20	21-30	31-40	41-50	51-60	61-70	71-80	81-100	
Mathematics-Science	72	112	298	571	735	614	313	124	2,839
Other	6	16	17	26	30	10	4	0	109
Totals	78	128	315	597	765	624	317	124	2,948

$Chi^2 = 52.49$; $df = 7$; $p < .01$

Table XIII shows the means of the two groups of scores. The t-test[2] shows that the difference between the two means is significant well beyond the .01 level. The

[2]An analysis of variance is unnecessary as there are only two means to be compared.

scores in Mathematics 30 of students whose teachers prefer teaching in the mathematics-science field are very much higher than those of students whose teachers prefer to teach in some other subject-field.

TABLE XIII

DATA FOR COMPARISON OF MEANS: MATHEMATICS 30 RESULTS CLASSIFIED BY TEACHERS' SUBJECT-FIELD PREFERENCE FOR TEACHING

	Teaching Preference	
	Mathematics-Science	Other
Number of Students	2,839	109
Sum of Scores	155,774.50	4,909.50
Mean	54.87	45.04
Variance	252.76	220.89

Homogeneity of Variances: $F = 1.14$; $F_{.01} = 1.00$

Summary

The statistical analysis has brought out a significant positive relation between students' mathematics results and each of the four teacher characteristics used in the study. The results of the t-test show that this relation is very significant in two cases, the number of mathematics courses

taken by the teachers and their subject-field preference for teaching. In the two remaining cases, the number of years of training and the number of years of experience, the relation is less significant.

III. THE MAJOR PROBLEM: A FURTHER ANALYSIS

The relation between student results and teacher characteristics is investigated further through a two-way analysis of variance.[3] Such an analysis brings out not only the individual significance of each of the two teacher characteristics used in the classification of students' results, but also the significance of various combinations of both characteristics.

For this analysis, the sample has been reduced to contain only those teachers who had indicated preference for teaching in the mathematics-science field (205 in number, involving 2,708 students). The teacher characteristics used as the basis for classifying student results are the number of years of academic and professional training beyond Grade XII, the number of university-level mathematics courses

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[3]The method used to carry out the analysis of variance is that described in Helen M. Walker and Joseph Lev, Statistical Inference (New York: Henry Holt and Company, 1953), pp. 381-382. This method gives only approximate results; its use in this part of the study was made necessary by the fact that the number of students is not the same throughout the nine groups of each classification.

taken, and the number of years of teaching experience.

The data for the three classifications that result are presented in Tables XIV(a) to XVI(b), pages 55 to 66. In each case the first table presents a summary of the data for the analysis of variance, indicating also the degree of homogeneity of variance, and the second table gives a summary of the analysis. The summary of the analysis indicates the degree of significance of the three F-values (rows, columns, and interaction). A significant F-value for rows indicates that the teacher characteristic used to classify students' results vertically is significantly related to the results; this relation is independent of any relation that may exist between results and the characteristic used in the horizontal classification. Similarly, a significant F-value for columns indicates that the teacher characteristic used in the horizontal classification is significantly related to results, independently of the relation between results and the characteristic used in the vertical classification. If the F-value for interaction is significant, the indication is that both teacher characteristics acting together are related to students' results but this relation is not uniform; some combinations of the two characteristics are more significant than are others.

The Analysis with Results Classified Relative to Training and Mathematics Courses

Tables XIV(a) and XIV(b), pages 55 and 56, present the data and summary of the analysis of variance for students' mathematics results classified according to the number of years of academic and professional training of the teachers and the number of university-level mathematics courses taken by the teachers.

The summary shows a very significant F-value (23.86) for the three row means, 51.46, 54.99, and 57.70. (These are the means of the students' scores grouped by the number of mathematics courses taken by the teachers). When the t-test is applied, the differences among the means are found to be significant at the .01 level of significance. Thus, for this group of teachers, the number of university-level mathematics courses taken bears a very significant positive relation to students' results in the final examination in mathematics.

The F-value for columns (2.85) just falls short of significance at the .05 level (Table XIV(b)). However, the fact that the differences among the column means seem relatively large, combined with the fact that the method of analysis used does not yield exact results,[4] suggests that the means may be significantly different even though the

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[4]See footnote 3, page 52.

TABLE XIV(a)

DATA FOR ANALYSIS OF VARIANCE: MATHEMATICS 30 RESULTS CLASSIFIED HORIZONTALLY BY NUMBER OF YEARS OF ACADEMIC AND PROFESSIONAL TRAINING OF TEACHERS AND VERTICALLY BY NUMBER OF UNIVERSITY-LEVEL MATHEMATICS COURSES TAKEN BY TEACHERS

Number of Mathematics Courses		Years of Training			Totals and Mean
		Less than 5	5 but less than 6	6 or more	
2 or less		(1)	(2)	(3)	
	Number of Students	536	145	52	733
	Sum of Scores	27,548.00	7,637.50	2,536.00	37,721.5
	Mean	51.40	52.67	48.77	51.46
	Variance	262.63	206.49	275.85	
3 or 4		(4)	(5)	(6)	
	Number of Students	659	203	231	1,093
	Sum of Scores	35,384.50	11,026.50	13,690.50	60,101.50
	Mean	53.69	54.32	59.35	54.99
	Variance	250.61	226.19	253.99	
5 or more		(7)	(8)	(9)	
	Number of Students	201	250	431	882
	Sum of Scores	11,095.50	14,365.00	25,430.50	50,891.00
	Mean	55.20	57.46	59.00	57.70
	Variance	216.83	192.56	249.67	
Total Number of Students		1,396	598	714	2,708
Total Sum of Scores		74,028.00	33,029.00	41,657.00	148,714.00
Mean		53.03	55.23	58.34	54.92

Homogeneity of Variances: $F_{max} = 1.43$; $F_{.01} = 1.00$

F-value does not indicate any significance. When the t-test is applied, all mean differences are found to be significant at the .01 level. For this group of teachers, again, the analysis brings out a significant positive relation between the number of years of academic and professional training and the students' mathematics examination results.

TABLE XIV(b)

SUMMARY OF ANALYSIS OF VARIANCE
FOR DATA OF TABLE XIV(a)

Source of Variation	Sum of Squares	Degrees of Freedom	Variance	F	$F_{.05}$	$F_{.01}$
Rows (Mathematics Courses)	64.66	2	32.33	23.86	2.99	4.60
Columns (Training)	7.73	2	3.87	2.85	2.99	4.60
Interaction	26.16	4	6.54	4.83	2.37	3.32
Error		2699	1.36			

Table XIV(b) shows also that the F-value for interaction (4.83) is significant beyond the .01 level of significance. The indication is that some combinations of mathematics courses and training are more significantly related to students' results than are others. The signifi-

cance of various combinations is revealed by a comparison of the means of the groups.

The means of Groups (6) and (9) (59.35 and 59.00, respectively), are the highest of the nine means. They differ significantly from all the other means except that of Group (8). (The differences are significant at the .01 level). This fact means that the best results in the Mathematics 30 final examination were obtained by students of teachers who had six or more years of training and three or more courses in mathematics. These results, however, are not significantly different from those of students whose teachers had five but less than six years of training and five or more mathematics courses (Group (8)).

The lowest mean is that of Group (3). However, the t-test does not bring out any significant differences between it and the mean of either Group (1) or Group (2). Neither do the latter two differ significantly from each other. These facts indicate that the competence of teachers having two or less mathematics courses is not improved with increase in training. (The criterion of competence is, of course, students' results in the mathematics examination).

An interesting comparison is that of Groups (3) and (7). The difference in means is significant at the .01 level. The fact that the mean of Group (7) is the larger indicates that of the teachers studied, those with many

mathematics courses (five or more) and little training (less than five years) are more competent than those with much training (six years or more) and few mathematics courses (two or less).

Finally, it is worth while to compare Groups (1), (5), and (9). Considered in that order, these groups represent consistent increases in the amount of training that the teachers have had and in the number of mathematics course that they have taken. The t-test shows that the mean of Group (5) exceeds the mean of Group (1) at the .05 level and that the mean of Group (9) exceeds the means of Groups (5) and (1) at the .01 level. This result indicates that consistent increases in the amount of training and in the number of mathematics courses are accompanied by a significant increase in teaching competence.

The Analysis with Results Classified Relative to Mathematics Courses and Experience

Tables XV(a) and XV(b), pages 60 and 61, present the data and summary of the analysis of variance for students' mathematics results classified relative to the number of mathematics courses taken by the teachers and the number of years of teaching experience that these teachers have had.

Table XV(b) shows a highly significant F-value for columns (mathematics courses). (F=11.09, which is signifi-

cant beyond the .01 level). This result is necessarily in accord with that established about the same characteristic in Table XIV(b). Hence, the same interpretation results as was given there.

The F-value for rows (experience) is 6.19. The summary (Table XV(b)) indicates that this value is significant beyond the .01 level. When the three row means (53.32, 55.11, and 55.27) are compared and the differences tested by the t-test, the only difference found to be significant (.05 level) is that between the third mean and the first. This result shows that teachers with twenty or more years of experience are more competent than teachers with nine or less years of experience; apart from this difference, there is no significant difference in competence amongst the three groups of teachers. The indication, then, is that for teachers who prefer teaching in the mathematics-science field, there is a fairly significant positive relation between teaching experience and students' results in the mathematics examination.

The F-value for interaction is also highly significant. ($F=6.20$, which is significant at the .01 level). Examination of the separate groups of Table XV(a) again reveals some interesting combinations.

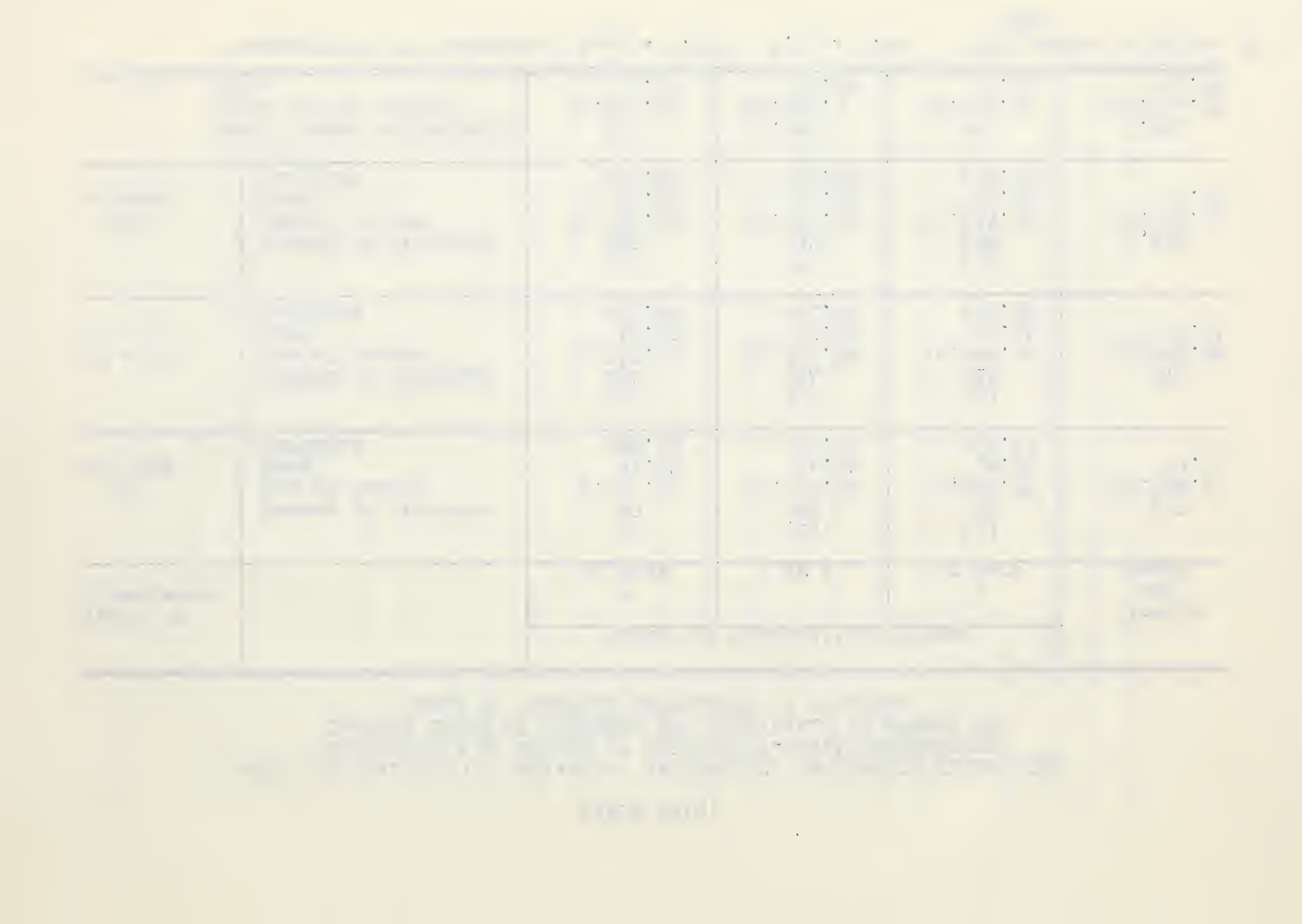
The highest mean is that of Group (6) (59.34). Its difference from the mean of every other group, except Group

TABLE XV(a)

DATA FOR ANALYSIS OF VARIANCE: MATHEMATICS 30 RESULTS CLASSIFIED HORIZONTALLY BY NUMBER OF UNIVERSITY-LEVEL MATHEMATICS COURSES TAKEN BY TEACHERS AND VERTICALLY BY NUMBER OF YEARS OF TEACHING EXPERIENCE OF TEACHERS

Years of Experience		Number of Mathematics Courses			Totals and Means
		2 or less	3 or 4	5 or more	
9 or less		(1)	(2)	(3)	
	Number of Students	97	292	38	427
	Sum of Scores	4,953.50	15,926.00	1,889.00	22,768.5
	Mean	51.07	54.54	49.71	53.32
	Variance	150.45	227.16	340.17	
10 - 19		(4)	(5)	(6)	
	Number of Students	234	264	318	816
	Sum of Scores	11,547.00	14,552.00	18,869.00	44,968.00
	Mean	49.35	55.12	59.34	55.11
	Variance	283.50	261.22	200.38	
20 or more		(7)	(8)	(9)	
	Number of Students	402	537	526	1,465
	Sum of Scores	21,221.00	29,623.50	30,133.00	80,977.50
	Mean	52.79	55.16	57.29	55.27
	Variance	256.08	259.48	230.65	
	Total Number of Students	733	1,093	882	2,708
	Total Sum of Scores	37,721.50	60,101.5	50,891.00	148,714.00
	Mean	51.46	54.99	57.70	54.92

Homogeneity of Variances: $F_{max} = 2.26$*; $F_{.01} = 1.00$ *This value is quite high.



(9), is significant at the .01 level. This fact indicates that of the teachers studied, the most competent are those with five or more mathematics courses and ten to nineteen years of experience. Their competence, however, is not much different from that of teachers with five or more mathematics courses and twenty or more years of experience.

TABLE XV(b)

SUMMARY OF ANALYSIS OF VARIANCE
FOR DATA OF TABLE XV(a)

Source of Variation	Sum of Squares	Degrees of Freedom	Variance	F	$F_{.05}$	$F_{.01}$
Rows (Experience)	19.17	2	9.59	6.19	2.99	4.60
Columns (Mathematics Courses)	34.38	2	17.19	11.09	2.99	4.60
Interaction	38.46	4	9.62	6.20	2.37	3.32
Error		2699	1.55			

The lowest mean is that of Group (4) (49.35). Its difference from the mean of every other group, except Groups (1) and (3), is significant at the .01 level. The least competent of the group of teachers studied, then, are those having two or less mathematics courses and ten to nineteen

years of teaching experience. However, their competence is not significantly different from that of teachers having nine or less years of experience and having either two or less mathematics courses (Group (1)) or five or more mathematics courses (Group (3)).

A rather interesting result is revealed by a study of Groups (2), (5), and (8), which represent the teachers who have taken three or four mathematics courses. There are no significant differences among the means of these three groups. This fact indicates that for teachers who have taken three or four university-level mathematics courses, the amount of teaching experience bears no significant relation to the quality of students' results in mathematics.

A similar result with respect to the effect of mathematics courses holds for Groups (1), (2), and (3), which represent teachers with nine or less years of experience. The means of students' scores in these three groups do not differ significantly from each other. The indication is that the number of mathematics courses taken is of no significance in the competence of mathematics teachers with nine or less years of teaching experience.

A comparison of the means of Groups (3) and (7) shows no significant difference in students' scores. The interpretation is that there is no significant difference in competence between teachers with many mathematics courses

(five or more) and little teaching experience (nine years or less) and teachers with few mathematics courses (two or less) and much experience (twenty years or more).

The most consistent significant increase in means is shown by Groups (4), (5), and (6), which represent teachers with ten to nineteen years of experience. The t-test shows all three mean differences to be significant at the .01 level. It is clear from this result that the positive relation between mathematics training and teaching competence is most significant in the case of teachers having ten to nineteen years of teaching experience.

Finally, Groups (1), (5), and (9), considered in that order, represent successive increases in both length of experience and number of mathematics courses. A comparison of the means of the three groups (in the same order) shows that the differences increase significantly. (The difference in means between Groups (5) and (1) is significant at the .05 level; between (9) and (5), at the .01 level). This result means, then, that consistent increases in the length of the teachers' experience and in the amount of their mathematical training are accompanied by significant improvement in their competence.

The Analysis with Results Classified Relative to Experience and Training

The data for the third two-way analysis of variance are presented in Table XVI(a) where students' scores in the Mathematics 30 examination have been classified relative to the teaching experience and the academic and professional training of the teachers. The summary of the analysis is contained in Table XVI(b), page 66.

The summary confirms what has already been established about the relation between students' results and length of training (Table XIV(b)) and the relation between students' results and length of experience (Table XV(b)). The summary also indicates a very significant interaction. ($F=11.84$, which is significant well beyond the .01 level.) Quite clearly, training and experience do not function independently throughout the nine groups of the classification.

The highest mean is that of Group (9) (59.56). It differs significantly (.01 level) from the means of all other groups but Groups (5) and (8). The most competent group of teachers in this classification, then, are teachers who have combined six or more years of training with twenty or more years of experience. Their competence, however, is not significantly different from that of teachers with five or more years of training and ten to nineteen years of experience (Groups (5) and (8)).

TABLE XVI(a)

DATA FOR ANALYSIS OF VARIANCE: MATHEMATICS 30 RESULTS CLASSIFIED HORIZONTALLY BY NUMBER OF YEARS OF TEACHING EXPERIENCE OF TEACHERS AND VERTICALLY BY NUMBER OF YEARS OF ACADEMIC AND PROFESSIONAL TRAINING OF TEACHERS

Years of Training		Years of Experience			Totals and Mean
		9 or less	10 - 19	20 or more	
Less than 5		(1)	(2)	(3)	
	Number of Students	313	422	661	1,396
	Sum of Scores	16,871.50	22,221.00	34,935.50	74,028.00
	Mean	53.90	52.66	52.85	53.03
	Variance	223.01	269.64	278.01	
5 but less than 6		(4)	(5)	(6)	
	Number of Students	85	152	361	598
	Sum of Scores	4,607.50	8,766.00	19,655.50	33,029.00
	Mean	54.21	57.67	54.45	55.23
	Variance	190.09	251.21	196.12	
6 or more		(7)	(8)	(9)	
	Number of Students	29	242	443	714
	Sum of Scores	1,289.50	13,981.00	26,386.50	41,657.00
	Mean	44.47	57.77	59.56	58.34
	Variance	236.86	228.31	263.85	
Total Number of Students		427	816	1,465	2,708
Total Sum of Scores		22,768.50	44,968.00	80,977.5	148,714.00
Mean		53.32	55.11	55.27	54.92

Homogeneity of Variances: $F_{max} = 1.46$; $F_{.01} = 1.00$

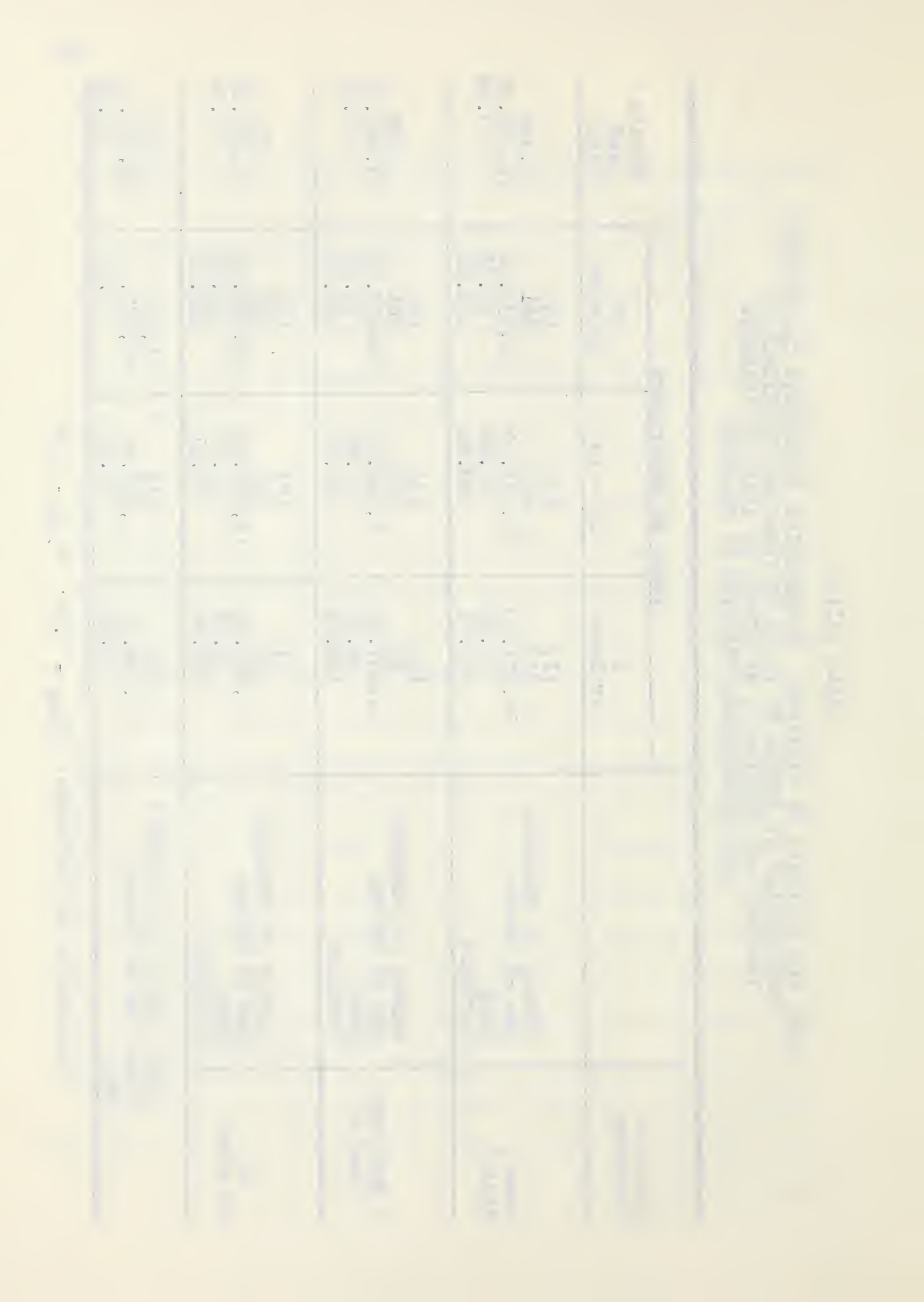


TABLE XVI(b)

SUMMARY OF ANALYSIS OF VARIANCE
FOR DATA OF TABLE XVI(a)

Source of Variation	Sum of Squares	Degrees of Freedom	Variance	F	$F_{.05}$	$F_{.01}$
Rows (Training)	10.08	2	5.04	2.70	2.99	4.60
Columns (Experience)	43.04	2	21.52	11.51	2.99	4.60
Interaction	88.57	4	22.14	11.84	2.37	3.32
Error		2699	1.87			

The lowest mean is that of Group (7) (44.47). Its difference from the mean of every other group is significant at the .01 level. This fact indicates that the least competent of the teachers are those with six or more years of training and nine or less years of experience.

A comparison of the means of Groups (1), (2), and (3) fails to bring out any significant differences. The relation between experience and competence in the case of teachers with less than five years of training is therefore insignificant.

When the means of Groups (3) and (7) are compared, the mean of Group (3) is found to be significantly higher than that of Group (7). (The difference is significant at

the .01 level.) Thus, teachers who combine twenty years or more of experience with less than five years of training are more competent than teachers who combine nine years or less of experience with six years or more of training.

Finally, the t-test shows that the mean of Group (5) exceeds the mean of Group (1) at the .05 level of significance and that the mean of Group (9) exceeds the mean of Group (1) at the .01 level. (The means of Groups (5) and (9) do not differ significantly.) The indication is that there is a fairly significant increase in teacher competence when the amounts of training and experience are consistently increased.

Summary

This part of the study has used the mathematics examination results of students whose teachers had indicated preference for teaching in the mathematics-science field.

The analysis brings out a significant positive relation between these results and each of the three teacher characteristics, number of years of training, number of years of teaching experience, and number of mathematics courses taken. It shows also that the two teacher characteristics used in each classification of students' mathematics results do not function independently, but interact very significantly. The interaction is accompanied by change in students' results, the actual change being closely related to the specific

combination of the two teacher characteristics. The analysis indicates, for example, that consistent increases in the two teacher characteristics are accompanied by consistent improvement in students' mathematics results, and that, in general, the highest results are obtained by the students of those teachers in whom each of the two characteristics is present to a large degree.

CHAPTER V

FINDINGS, CONCLUSIONS, AND IMPLICATIONS

This study investigated the competence of Grade XII mathematics teachers who were teaching in Alberta schools during 1957-58. Their competence was measured in terms of the results of their students in the Mathematics 30 final examination of June, 1958. Four objectively measurable characteristics of the teachers were used as components of competence: (1) the number of years of academic and professional training beyond Grade XII; (2) the number of university-level mathematics courses taken; (3) the number of years of teaching experience; (4) the subject-field preference for teaching. One major problem and two minor ones were investigated.

I. FINDINGS AND CONCLUSIONS

The Minor Problems

The first minor problem. Are there any significant differences between teachers in city school systems and teachers in non-city systems with respect to four selected characteristics?

Comparison of the teachers with respect to the length of their academic and professional training has shown a highly significant difference between the two groups; city

teachers have more training than do non-city teachers (pages 33 and 34). This finding supports that reported by Lindstedt in his study of Grade IX mathematics teachers in Alberta (page 24). The fact that city teachers surpass non-city teachers in training is no doubt a consequence of the policy of selectivity followed by city systems. On the assumption that training is a significant factor in teacher competence, city school systems tend to employ only those teachers who have had much training. This practice seems to be true especially at the Grade XII level, where only the highly trained teachers are placed.

When the two groups of teachers were compared with respect to the number of university-level mathematics courses that they have taken, the difference was again found to be highly significant; city teachers have taken more mathematics courses than have non-city teachers (pages 34 and 35). This finding again agrees with that reported by Lindstedt about Grade IX teachers (page 24). It is further evidence of the greater selectivity exercised by city school systems but it is also evidence of the fact that an extensive amount of academic and professional training on the part of the teacher is usually accompanied by a significant amount of specialized training in a subject field. In Alberta, teachers taking two or more years of professional training are generally required to take content courses in a special subject field,

and the number of these courses required usually increases with the number of years of training. Again, a teacher with five or six years of training usually has a Bachelor of Education degree and another degree in some major field of study. In the case of mathematics teachers, this field is most often the mathematics-science field, a degree in which requires a substantial number of mathematics courses. Thus, after a point, the number of mathematics courses taken is commensurate with the number of years of training.

Comparison of the two groups of teachers on the basis of the length of their teaching experience revealed some difference; city teachers have more experience than do non-city teachers but the difference is not very great (pages 35 and 36). The fact that city teachers are somewhat more experienced than non-city teachers is perhaps again attributable to the selectivity factor (the assumption being that competence increases with experience). City systems, unlike non-city systems, rarely assign inexperienced teachers to subjects at the Grade XII level, even though they may be well qualified in terms of training. The Grade XII teacher in a city system, in general, has attained his position as a result of demonstrated ability to teach; the proof of ability takes time, during the course of which the teacher gains experience.

Lindstedt had found no significant difference in

experience between city teachers and non-city teachers (page 24).

Finally, when the two groups of teachers were compared with respect to their subject-field preference for teaching, no significant difference was revealed (pages 36 and 37). The majority of the teachers in each group, city and non-city, prefer to teach in the mathematics-science field. This finding does not support that of Lindstedt at the Grade IX level; he had found that a far greater proportion of city teachers than non-city teachers prefer to teach in the mathematics-science field (page 24).

To summarize, this study has found some significant differences between city school teachers and non-city school teachers. City teachers surpass non-city teachers very significantly in length of academic and professional training and in extent of mathematical background, but not very significantly in length of teaching experience. The two groups do not differ significantly in their subject-field preference for teaching.

The second minor problem. Are there any significant differences between students in city school systems and students in non-city systems with respect to their results in the final examination in mathematics?

This study shows that there is a highly significant difference between the two groups of students; the results

of the city students are very much higher than those of the non-city students (pages 37 and 38). This finding disagrees with that reported by Lindstedt at the Grade IX level; he had found no significant difference in mathematics results between city students and non-city students (page 24).

Considered together, the findings of the two minor problems bring out an interesting result: The differences between city teachers and non-city teachers with respect to three selected characteristics are significantly reflected in the mathematics achievement of the students of these teachers. That this is so is an indication that the three characteristics, length of academic and professional training, extent of mathematical preparation, and length of teaching experience, are closely related to the competence of the teachers that were studied.

The Major Problem

Do differences in the four selected characteristics of Grade XII mathematics teachers reflect significant differences in the results of the students of these teachers in the final examination in mathematics?

Training. The specific results of the basic analysis (chi-square and one-way analysis of variance, pages 40 to 43), show that differences in the number of years of academic and professional training of the teachers do reflect significant differences in the mathematics results of the students.

There is some difference in mathematics achievement between students whose teachers have had less than four years of training and students whose teachers have had four but less than five years of training. The student achievement of teachers with five but less than six years of training is significantly higher than that of teachers with less than four years of training, but it is not very much higher than that of teachers with four but less than five years of training. The student achievement of teachers with six or more years of training surpasses that of every other group of teachers. These results indicate that there is a significant positive relation between student achievement in mathematics and the length of the teachers' academic and professional training.

The results of the t-test in the further analysis using those teachers who prefer to teach in the mathematics-science field (pages 54 and 56), lead to the same conclusion: Student achievement increases when the length of the teachers' training increases.

This study, then, has found that the length of the teachers' academic and professional training is significantly related to their competence. This finding agrees with that of Rogers (page 10). It also supports that reported by Lindstedt (page 22) but it is far more definite.

Mathematics courses. The results of the basic analysis

(pages 44 to 46) indicate also that differences in the number of university-level mathematics courses taken by the teachers reflect significant differences in the students' mathematics results. The mean of student achievement in mathematics increases very significantly as the number of mathematics courses taken by the teachers increases consistently from one or none to six or more. The most competent teachers are those who have had six or more mathematics courses; the least competent, those who have had only one or none. The same general result was established by the two-way analysis of variance (pages 54 and 56).

This study has found, then, that the extent of the teachers' preparation in mathematics is significantly related to their competence in teaching mathematics. This finding supports that of Hughes (page 10) and one of the findings of Davis (page 11). However, it disagrees with the findings of the remaining studies reviewed (Chapter II), including Lindstedt's study of Grade IX mathematics teachers (page 23).

Experience. According to the results of the basic analysis (pages 47 to 49), differences in the number of years of teaching experience of the teachers reflect some significant differences in the mathematics results of the students. The student achievement in mathematics of teachers with nine or less years of teaching experience is not significantly different from either that of teachers with ten to nineteen

years of experience or that of teachers with thirty-five or more years of experience. However, the student achievement of teachers with ten to nineteen years of experience is significantly higher than that of teachers with thirty-five or more years of experience, and the student achievement of teachers with twenty to thirty-four years of experience surpasses that of each of the other three groups. These results indicate that there is a fairly significant relation between the length of the teachers' experience and the students' achievement in mathematics. The same general result was established by the two-way analysis of variance (pages 58 to 61).

Thus, this study has established that the experience of the teachers bears a fairly significant relation to their competence. This finding confirms the findings of Rogers (page 15), Davis (page 16), Schunert (page 16), Stephens and Lichenstein (page 16), and Betts (page 18). It also agrees with some of Lindstedt's findings (pages 22 and 23) but it is more consistent.

Subject-field preference. The results of the analysis (pages 50 and 51) show clearly that differences in the teachers' subject-field preference for teaching reflect a significant difference in the students' achievement in mathematics. The mathematics examination results of students whose teachers prefer to teach in the mathematics-science

field are very much higher than those of students whose teachers prefer to teach in a different subject field.

This study has found, then, that subject-field preference for teaching is very significantly related to the competence of mathematics teachers. This finding confirms that reported by Lindstedt in his study at the Grade IX level (page 23).

Further findings. The further analysis of the major problem (pages 52 to 68), which considered only the three teacher characteristics, training, mathematics courses, and experience, has brought out an interesting result relating to the interaction of these three characteristics. It has shown that the two teacher characteristics used in each classification of students' mathematics results do not function independently, but interact very significantly. The interaction is accompanied by change in students' results, the actual change being closely related to the specific combination of the two characteristics. The two most significant findings of the study in this respect are that successive increases in the two teacher characteristics are accompanied by an increase in teacher competence, and that those teachers are most competent in whom each of the two characteristics is present to a large degree.

Summary. This study has found a significant positive relation between each of the four selected characteristics

of Grade XII mathematics teachers in Alberta schools (1957-58) and the results of the students of these teachers in the Mathematics 30 final examination. The competence of these teachers, then, is significantly related to the number of years of academic and professional training that these teachers have had, to the number of university-level mathematics courses that they have taken, to the length of their teaching experience, and to their subject-field preference for teaching.

Summary of Findings and Conclusions

This study, which investigated the competence of Grade XII mathematics teachers in Alberta schools in 1957-58, reports the following findings and conclusions:

1. There are some significant differences between teachers in city school systems and teachers in non-city systems. City teachers surpass non-city teachers very significantly in length of academic and professional training and in number of university-level mathematics courses taken, but not very significantly in length of teaching experience. The two groups do not differ significantly in their subject-field preference for teaching.

2. There is a significant difference in results in the Mathematics 30 final examination between students in city school systems and students in non-city systems. The results of city students are much higher than those of non-city students.

3. There is a significant positive relation between teacher competence (as measured by students' results in the Mathematics 30 final examination) and each of the four teacher characteristics, length of academic and professional training beyond Grade XII, number of university-level mathematics courses taken, length of teaching experience, and subject-field preference for teaching.

4. The three teacher characteristics, training, mathematics courses, and experience, do not function independently in teacher competence. Increases in any two of the characteristics interact and are accompanied by an increase in competence.

The following findings and conclusions are common to the present study and that of Lindstedt (pages 20 to 24). They apply to both the Grade IX and Grade XII mathematics teachers in Alberta schools in 1957-58.

1. City teachers differ significantly from non-city teachers in the length of their academic and professional training and in the number of university-level mathematics courses that they have taken.

2. There is a significant relation between teacher competence (as measured by students' results in the final examination in mathematics) and each of the three teacher characteristics, length of academic and professional training beyond Grade XII, length of teaching experience, and subject-field preference for teaching.

3. Increases in length of training and in length of experience interact and are accompanied by an increase in competence.

II. IMPLICATIONS

Examination of the findings and conclusions summarized above reveals that the present study has important implications in several areas of teacher competence.

Further Research

A fairly definite implication of this study is the need for further research on teacher competence, particularly the competence of Alberta teachers. The same general sources of data as those used in the present study should be used for further research to complement the findings of this study. Specifically, similar studies should be carried out in other subject areas. The findings in these areas may be different; the composite results for all Grade XII subjects would be interesting and informative. Also, for similar reasons, further studies should be carried out at the Grade IX level. The fact that there are some differences between the findings of the present study at the Grade XII level and those of Lindstedt's study at the Grade IX level may imply that there are real differences between these two levels of teachers with respect to the nature of teaching competence. Further

research should be undertaken to ascertain the extent of these differences.

Teacher-Training Programs

This study has significant implications for the programs of institutions responsible for the training of mathematics teachers. It suggests that mathematics teachers have a minimum of four years of training[1] but that for maximum competence, the length of training should be at least six years. It implies further that the training program allow for an extensive background of content courses in mathematics. This latter statement, however, does not seem to apply to teachers of Grade IX mathematics. Lindstedt had found that the number of mathematics courses taken by Grade IX mathematics teachers was not significantly related to the competence of these teachers (page 23). Thus, there may be implications here concerning the differentiation of training programs for teachers of different grade levels of mathematics, particularly with respect to the nature of the background content courses that should be included in such programs.

The study also points out the desirability of combining training with experience. The implication may be

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[1]This suggestion agrees with Recommendation 140(a), Report of the Royal Commission on Education (Edmonton: Government of Alberta, The Queen's Printer, 1959), p. 187.

that the practice-teaching courses now included in teacher-training programs should be increased in number or length, or both; or the implication may be that some type of internship should be introduced into the training program. In this respect, two recommendations of the Alberta Royal Commission on Education are worthy of note. These recommendations state

> 140.(b) that during the first two years but not within the university term the candidate must complete three months of practice teaching;
>
> (c) that on the completion of two years of training the candidate may serve an internship of one year, after which he will return to continue his university course, in which regard at least one full academic year intramurally must be required.[2]

These recommendations indicate a realistic and practical approach to the problem of combining training and experience.

Teachers' Salaries

Because length of academic and professional training and length of teaching experience are key factors in the structure of teachers' salary schedules, the results of this study have some implications in this area. This study, while it does not set out any specific plan in this respect, does bring out some points that might be considered in the setting up of a salary scale that recognizes teacher competence. It does imply, for example, (for Alberta Grade

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[2] Ibid.

XII mathematics teachers, at least) that salary increments for training in the fifth and sixth years should be at least as great as those in the third and fourth years, and not smaller, as they presently are in many cases. It implies, similarly, that the length of experience recognized for salary purposes should be far greater than that presently recognized. (In the majority of cases at present, it does not exceed twelve years.)

However, perhaps the most significant implication of this study in the area of teachers' salaries is the confirmation of the present practice of paying teachers on the basis of training and experience, especially when training has included content courses in a subject field. The question of whether teachers should be paid on such a basis is a very live one and one which has evoked "much heat with little light." This study is basic in throwing light on the issue as it concerns Grade XII mathematics teachers in Alberta.

Teacher Placement

The implication of this study for personnel in charge of teacher placement is fairly definite: Teachers appear to be most effective in their preferred subject field; circumstances permitting, consideration should be given to subject-field preference when a teacher is being appointed.

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APPENDICES

APPENDIX A

EXTRACT OF ITEMS FROM THE QUESTIONNAIRE PREPARED BY THE ROYAL COMMISSION ON EDUCATION FOR THE SURVEY OF THE ALBERTA TEACHER FORCE

11. In what TYPE OF ADMINISTRATIVE UNIT is your school? If it is in a School Division or County, check under A. If it is in an Independent (Non-Divisional) District, check ONE under B.

A. ..... In a School Division or County.

B. In an Independent (Non-Divisional) District.

1 .... A City District (not R.C. Separate)
2 .... A Town District (not R.C. Separate)
3 .... A Village District (not R.C. Separate)
4 .... A Consolidated District (not R.C. Separate)
5 .... A Rural School District (not R.C. Separate)
6 .... A City District (R.C. Separate)
7 .... A Town District (R.C. Separate)
8 .... A Village or Rural District (R.C. Separate)
9 .... Other (Please write in)

.....

15. What is the EXTENT of your TOTAL ACADEMIC and PROFESSIONAL PREPARATION BEYOND HIGH SCHOOL? Check ONE.

1 .... Less than a standard 1-year program (7 months) in a Normal School, Teachers' College, or University.
2 .... A standard 1-year program (7 months or more) in a Normal School, Teachers' College, or University.
3 .... 2 complete years but less than 3 in a University and/or Teachers' College
4 .... 3 complete years but less than 4 in a University and/or Teachers' College.
5 .... 4 complete years but less than 5 in a University and/or Teachers' College.
6 .... 5 complete years but less than 6 in a University and/or Teachers' College.
7 .... 6 or more complete years in a University and/or Teachers' College.

22. (a) How many University or College CONTENT COURSES have you completed in MATHEMATICS? Encircle ONE.
None 1 2 3 4 5 6 7 8+
(b) List Mathematics courses completed:

.....

.....

40. In which of the following subject areas would you PREFER to teach? Check ONE.

1 .... English-Social Studies (Jr. or Sr. High).
2 .... Mathematics-Science (Jr. or Sr. High).
3 .... Foreign Languages (Jr. or Sr. High).
4 .... Fine Arts (Jr. or Sr. High).
5 .... Physical Education (Jr. or Sr. High).
6 .... Indus. Arts-Home Ec. (Jr. or Sr. High).
7 .... Commercial Subjects (Jr. or Sr. High).
8 .... Grades I, II, or III.
9 .... Grades IV, V, or VI.
10 .... Other (Please write in) .....

41. Counting the present school year, what is the TOTAL NUMBER of SCHOOL YEARS of full-time teaching experience you have had? Check ONE.

1 .... 1 year
2 .... 2 years
3 .... 3 to 4 years
4 .... 5 to 9 years
5 .... 10 to 14 years
6 .... 15 to 19 years
7 .... 20 to 24 years
8 .... 25 to 34 years
9 .... Over 34 years

APPENDIX B

TEST OF REPRESENTATIVENESS OF SAMPLES

The test applied is the chi-square test of "goodness of fit."[1] In each case (Tables XVII to XIX, pages 91 and 92), the probability value (p) is greater than .05, indicating that the sample distribution is not significantly different from the expected distribution.

TABLE XVII

REPRESENTATIVENESS OF SAMPLE OF CITY STUDENTS

	Scores on Examination										Totals
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	
Sample	6	17	33	59	330	331	306	188	87	27	1,384
Expected	7	25	45	66	344	324	286	182	81	24	1,384

$Chi^2 = 9.78$; $df = 9$; $.30 < p < .40$

[1] George A. Ferguson, Statistical Analysis in Psychology and Education (New York: McGraw Hill Book Company, Inc., 1959), pp. 161-165.

TABLE XVIII

REPRESENTATIVENESS OF SAMPLE OF NON-CITY STUDENTS

	Scores on Examination										Totals
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	
Sample	33	66	98	137	437	438	330	150	65	4	1,758
Expected	36	69	100	143	448	437	320	140	61	4	1,758

$Chi^2 = 2.23$; $df = 9$; $.98 < p < .99$

TABLE XIX

REPRESENTATIVENESS OF TOTAL SAMPLE OF STUDENTS

	Scores on Examination										Totals
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	
Sample	39	83	131	196	767	769	636	338	152	31	3,142
Expected	42	93	143	208	792	760	608	324	143	29	3,142

$Chi^2 = 6.42$; $df = 9$; $.60 < p < .70$

APPENDIX C

TRANSFORMATION OF ACHIEVEMENT SCORES

The Data

Table XX, page 95, is a correlation table of the students' scores on the mathematics test and their scores on the mental ability test. The data used in transforming the mathematics scores are contained in this table and in the summary relevant to it following the table.

The Method[1]

Theory. If Y_i is the ith mathematics score and X_i the ith mental ability score, and if Y_i is considered as consisting of two parts, that is, if

$$Y_i = Y_i' + R_i$$

where

$$Y_i' = a + bX_i = \overline{Y} + b(X_i - \overline{X})$$

is the predicted Y based on X, and R_i is the residual containing those contributions to Y_i not explained by linear regression of Y on X, then the quantity

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[1]The writer is indebted to Mr. J. Y. Drolet, University of Laval, for proposing the method, and to Dr. J. R. MacGregor, University of Alberta, for deriving the proof. The theory of linear regression and correlation, on which this method is based, is discussed in J. F. Kenney and E. S. Keeping, Mathematics of Statistics, Part One (New York: D. Van Nostrand Company, Inc., 1954), pp. 252-281.

$$Z_i = Y_i + (\bar{Y} - Y_i') = \bar{Y} + R_i$$

is a transformation of Y_i that is uncorrelated with X_i.

Proof: From the definition of Z_i, it is easily shown that

$$\bar{Z} = \bar{Y}$$

Therefore

$$\begin{aligned} Z_i - \bar{Z} &= Y_i + (\bar{Y} - Y_i') - \bar{Y} \\ &= Y_i - Y_i' \\ &= Y_i - (\bar{Y} + b(X_i - \bar{X})) \\ &= (Y_i - \bar{Y}) - b(X_i - \bar{X}) \end{aligned}$$

Multiplying this equation by $(X_i - \bar{X})$, summing over the interval i=1 to i=N, and dividing by N, in turn, yields

$$\frac{1}{N}\sum(Z_i - \bar{Z})(\bar{X}_i - \bar{X}) = \frac{1}{N}\sum(Y_i - \bar{Y})(X_i - \bar{X}) - \frac{1}{N}b\sum(X_i - \bar{X})^2$$

or $$s_{zx} = s_{xy} - bs_x^2$$

But $$b = \frac{s_{xy}}{s_x^2} \qquad \text{so that} \qquad s_{xy} = bs_x^2$$

and therefore $s_{zx} = 0$

Now the correlation, r, between Z and X is given by

$$r = \frac{s_{zx}}{s_z s_x}$$

and since $s_{zx} = 0$, it follows that $r = 0$. Hence the Z_i and the X_i are uncorrelated, and Z can be regarded as a measure of mathematics achievement when mental ability is constant.

TABLE XX

CORRELATION TABLE OF STUDENTS' SCORES ON THE MATHEMATICS AND MENTAL ABILITY TESTS

Scores on Mathematics Test (Y)	Scores on Mental Ability Test (X)												Totals
	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	
96-100										1		6	7
91-95									4	4	12	4	24
86-90							1	3	1	16	14	16	51
81-85						4	4	5	13	21	26	28	101
76-80				1		2	7	3	19	28	34	16	110
71-75						5	12	24	47	59	56	25	228
66-70					7	8	16	30	68	94	73	25	321
61-65				2	4	12	23	29	68	78	79	20	315
56-60			1	5	5	13	36	45	69	83	61	18	336
51-55	3		1	6	12	23	45	63	99	82	74	25	433
46-50			1	6	9	23	35	41	60	50	44	13	282
41-45		1	3	15	15	32	75	78	99	85	73	9	485
36-40		1		4	7	5	12	10	16	14	12		81
31-35		3	2	4	9	14	14	22	17	17	10	3	115
26-30			2	5	1	7	5	12	10	14	4	1	61
21-25	1	3		4	3	5	8	14	19	7	4	2	70
16-20			2	2	2	7	4	13	11	7	3	2	53
11-15			1	1	3	4	5	6	5	4		1	30
6-10			1	1	5	5	3	4	4	3	3		29
1-5		1		1	4	1	1	2					10
Totals	4	9	14	57	86	170	306	404	629	667	582	214	3,142

$N = 3142$

$\bar{X} = 58.22$ $\quad \bar{Y} = 54.52$

$SD_x = 9.80$ $\quad SD_y = 16.81$

$r = .37$

$Y' = 54.52 + .64(X - 58.22)$

$= 17.39 + .64X$

Application to data. From the data of Table XX, page 95,

$$\bar{Y} = 54.52$$

$$Y' = 17.39 + .64X$$

and since $Z = Y + (\bar{Y} - Y')$

then, for these data,

$$Z = Y + (54.52 - (17.39 + .64X))$$

$$= Y - .64X + 37.13$$

This equation, $Z = Y - .64X + 37.13$, was used as a formula for transforming the scores.

To illustrate with reference to the data in the correlation table (page 95), the twelve students with mathematics scores in the interval 61-65 and mental ability scores in the interval 41-45 were given a transformed mathematics score of 73, calculated as follows:

$$Z = 63 - .64(43) + 37.13$$

$$= 72.61$$

$$= 73$$ (the midvalue of the interval 71-75).

The Mental Ability Test

The test used to measure the students' mental abilities was the Alberta Department of Education Grade IX General Test of June, 1955. This test is an Alberta adaptation of the 1950 edition of the Dominion Group Test of Learning Capacity, Intermediate, Form A.

The Dominion Test is a verbal test, originally prepared as a measure of Spearman's General Intelligence.[2] The publisher reports a correlation of .95 between the two forms of the test (A and B), and a "g" correlation of .93 for the whole test.[3]

The Department of Education has expressed the view that I.Q.'s may be reliably computed from the raw scores obtained by Alberta students on the General Test.[4]

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[2]Department of Educational Research, University of Toronto, Group Test of Learning Capacity (Intermediate), Manual of Directions and Keys (Toronto: The University of Toronto, 1944), p. 3.

[3]Ibid., p. 4.

[4]Department of Education, Province of Alberta, "Summary of Results and Guide to the Interpretation of the Grade IX Reading and General Tests Administered June, 1954" (Edmonton: The Province of Alberta, 1954), p. 2. (Mimeographed.)

APPENDIX D

CONDITIONS UNDERLYING ANALYSIS OF VARIANCE

The following conditions are associated with the statistical model and the measurement requirement underlying the F-test, which is basic to the analysis of variance:

> 1. The observations must be independent. That is, the selection of any one case from the population for inclusion in the sample must not bias the chances of any other case for inclusion, and the score which is assigned to any case must not bias the score which is assigned to any other case.
> 2. The observations must be drawn from normally distributed populations.
> 3. These populations must have the same variance (or, in special cases, they must have a known ratio of variances).
> 4. The variables involved must have been measured in at least an interval scale, so that it is possible to use the operations of arithmetic (adding, dividing, finding means, etc.) on the scores.
> 5. The means of these normal and homoscedastic populations must be linear combinations of effects due to columns and/or rows. That is, the effects must be additive.[1]

The first four of these conditions also underly the t-test, which has been used along with the F-test in this study.

In this study, Condition (1), independence of observations, has been satisfied by the method of classifying the mathematics scores. Condition (4), measurement in an interval scale, and Condition (5), additivity of effects,

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[1]Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw-Hill Book Company, Inc., 1956), p. 19.

have been assumed.

Condition (2), normality of population, is apparently not a strict requirement for practical purposes. Lindquist says

> In general, the F-distribution is so insensitive to the form of the distribution of the criterion measure that it hardly seems worthwhile to apply any statistical test to the data to detect non-normality. . . . Unless the departure from normality is so extreme that it can be easily detected by mere inspection of the data, the departure from normality will probably have no appreciable effect on the validity of the F-test, and the probabilities read from the F-table can be used as close approximations to the true probabilities.[2]

Inspection of the data of Table V, page 38 (bottom line), reveals no extreme departure from normality. The distribution of scores shows a slight negative skewness but appears quite normal about the mean, 54.32. In the light of the above statement by Lindquist, the writer is confident that the F-test was not invalidated by any non-normality of the data.

Condition (3), homogeneity of variance, appears also to have only small practical significance for the F-test. Lindquist says again

> . . . the heterogeneity must be quite extreme to be of any serious consequence. . . . In general, unless

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[2]E. F. Lindquist, Design and Analysis of Experiments in Psychology and Education (Boston: Houghton Mifflin Company, 1953), p. 86. Similar views have been expressed by Allen L. Edwards, Experimental Design in Psychological Research (New York: Rinehart and Company, Inc., 1960), p. 128, and George A. Ferguson, Statistical Analysis in Psychology and Education (New York: McGraw Hill Book Company, Inc., 1959), p. 240.

> the heterogeneity of . . . variance is so extreme as to be readily apparent upon inspection of the data, the effect upon the F-distribution will probably be quite negligible.[3]

In this study, Hartley's test was used to determine the degree of homogeneity of variance.[4] This test requires the calculation of the ratio of the largest variance to the smallest variance. This ratio, F_{max}, is then tested for significance in the usual way by the F-test. The F_{max} ratios so obtained in the analyses in this study (Chapter IV) were 1.19, 1.11, 1.15, 1.14, 1.43, 2.26, and 1.46, the value of F required for significance being 1.00. Of these values, only $F_{max} = 2.26$, Table XV(a), page 60, could be considered extreme. However, even this result is perhaps not as serious as it might appear. $F_{max} = 2.26$ has been calculated from the variances of Groups (1) and (3) (150.45 and 340.17); these are extremely small groups in comparison with the others. The variances of the seven remaining, larger groups are fairly homogeneous, ranging from 200.38 (Group (6)) to 283.50 (Group (4)), so that on the whole, the analysis of the data in that table (Table XV(a)) is probably quite accurate.

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[3]Lindquist, loc. cit. See also Edwards, op. cit., p. 32, and Ferguson, loc. cit.

[4]Helen M. Walker and Joseph Lev, Statistical Inference (New York: Henry Holt and Company, 1953), pp. 191-193.

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